sorbs oxygen and glows with formation of the black trioxide and blue tetroxide till it at last attains its maximum degree of oxidation. The specific gravity of metallic vanadium at 15° is 5·5. It is not soluble in either hot or cold hydrochloric acid ; strong sulphuric acid dissolves it on heating, giving a yellow solution ; hydrofluoric acid dissolves it slowly with evolution of hydrogen ; nitric acid of all strengths acts violently on the metal, evolving red nitrous fumes and yielding a blue solution ; fused with sodium hydroxide the metal dissolves with evolution of hydrogen, a vanadate being formed.

One sample yielded on oxidation a percentage increase of 77·94, whereas that calculated from metal to pentoxide is 77·98. Another preparation gave a percentage increase of 70·8, showing the presence of a small quantity of oxide. On treatment in a current of chlorine metallic vanadium burns and forms the reddish black tetrachloride ; heated in a current of pure nitrogen the mononitride is formed.

The properties of the compounds of vanadium with silicon and platinum are then described in the memoir.

XX. " On *Palæocoryne,* a genus of the Tubularine Hydrozoa from the Carboniferous formation." By Dr. G. MARTIN DUNCAN, F.R.S., Sec. Geol. Soc., and H. M. JENKINS, Esq., F.G.S. Received June 14, 1869.

(Abstract.)

Palæocoryne is a new genus containing two species, and belongs to a new family of the Tubularidæ. The forms described were discovered in the lower shales of the Ayrshire and Lanarkshire coal-field, and an examination of their structure determined them to belong to the Hydrozoa, and to be parasitic upon Fenestellæ. The genus has some characters in common with *Bimeria* (St. Wright), and the polypary is hard and ornamented. The discovery of the trophosome, and probably part of the gonosome of a tubularine Hydrozoon in the Palæozoic strata brings the order into geological relation with the doubtful Sertularian Graptolites of the Silurian formation, and with the rare medusoids of the Solenhofen stones.

XXI. BAKERIAN LECTURE.—" On the Continuity of the Gaseous and Liquid States of Matter." By THOMAS ANDREWS, M.D., F.R.S., &c. Received June 14, 1869.

(Abstract.)

In 1863 the author announced, in a communication which Dr. Miller had the kindness to publish in the third edition of his ' Chemical Physics,' that on partially liquefying carbonic acid by pressure, and gradually raising at the same time the temperature to about 88° Fahr., the surface of de-
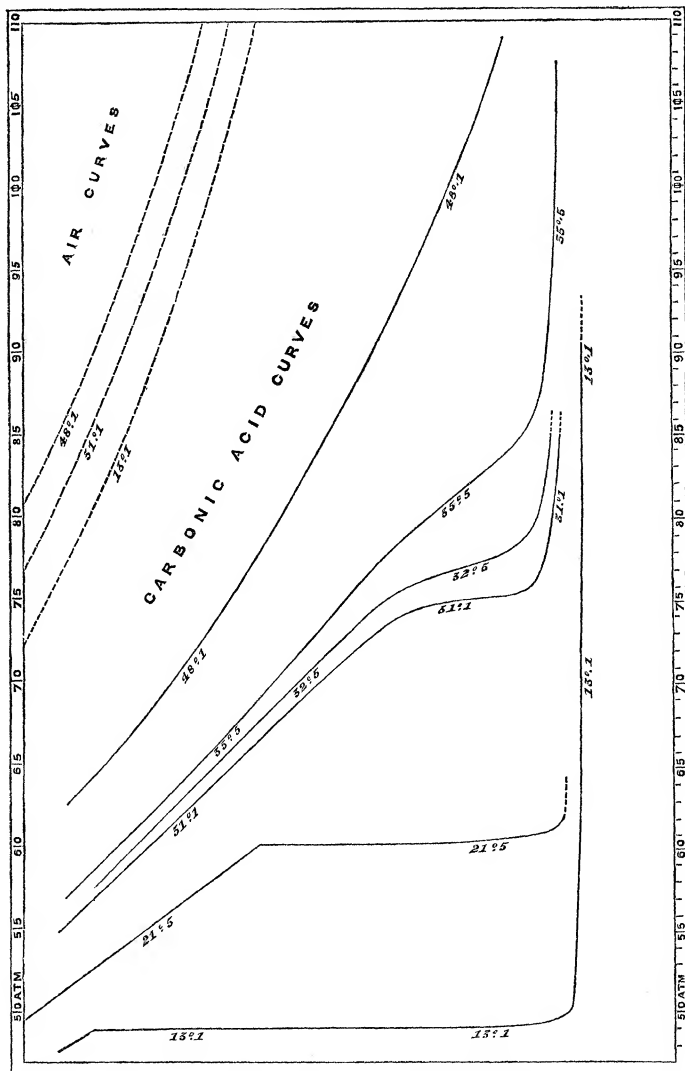
marcation between the liquid and gas became fainter, lost its curvature, and at last disappeared, the tube being then filled with a fluid which, from its optical and other properties, appeared to be perfectly homogeneous. The present paper contains the results of an investigation of this subject, which has occupied the author for several years. The temperature at which carbonic acid ceases to liquefy by pressure he designates the critical point, and he finds it to be 30°·92 C. Although liquefaction does not occur at temperatures a little above this point, a very great change of density is produced by slight alterations of pressure, and the flickering movements, also described in 1863, come conspicuously into view. In this communication, the combined effects of heat and pressure upon carbonic acid at temperatures varying from 13° C. to 48° C., and at pressures ranging from 48 to 109 atmospheres, are fully examined.

At 13°·1 C., and under a pressure, as indicated approximately by the air manometer, of 48·89 atmospheres, carbonic acid, now just on the point of liquefying, is reduced to $\frac{1}{80 \cdot 9}$ of the volume it occupied under one atmosphere. A slight increase of pressure, amounting to $\frac{1}{20}$ of an atmosphere, which has to be applied to condense the first half of the liquid, is shown to arise from the presence of a trace of air ($\frac{1}{1000}$ part) in the carbonic acid. After liquefaction, the volume of the carbonic acid, already reduced to about $\frac{1}{470}$ of its original volume, continues to diminish as the pressure augments, and at a much greater rate than in the case of ordinary liquids. Similar results were obtained at the temperature of 21°·5. A third series of experiments was made at 31°·1, or 0°·2 above the critical point. In this case the volume of the carbonic acid diminished steadily with the pressure, till about 74 atmospheres were attained. After this, a rapid but not (as in the case of liquefaction) abrupt fall occurred, and the volume was diminished to one-half by an additional pressure of less than two atmospheres. Under a pressure of 75·4 atmospheres, the carbonic acid was reduced to $\frac{1}{311}$ of its original volume under one atmosphere. Beyond this point it yielded very slowly to pressure. During the stage of rapid contraction there was no evidence at any time of liquefaction having occurred, or of two conditions of matter being present in the tube. Two other series of experiments were made, one at 32°·5, the other at 35°·5, with the same general results, except that the rapid fall became less marked as the temperature was higher. The experiments at 35°·5 were carried as far as 107 atmospheres, at which pressure the volume of carbonic acid was almost the same as that which it should have occupied if it had been derived directly from liquid carbonic acid, according to the law of the expansion of that body for heat.

The last series of experiments was made at 48°·1, and extended from 62·6 to 109·4 atmospheres of pressure. The results are very interesting, inasmuch as the rapid fall exhibited at lower temperatures has almost, if not altogether, disappeared, and the curve representing the changes of volume approximates closely to that of a gas following the law of Mariotte.

The diminution of volume is at the same time much greater than if that law held good.

The results just described are represented in a graphical form in the figure given below.   Equal volumes of air and carbonic acid, measured at

0° C. and 760 millimetres, when compressed at the temperatures marked on each curve, undergo the changes of volume indicated by the form of the curve.   The figures at the top and bottom indicate the approximate pres-

sures in atmospheres; the volumes of the gas and air are measured upwards from the dotted horizontal line.

The author has exposed carbonic acid, without making precise measurements, to higher pressures than any of those mentioned, and has made it pass, without breach of continuity, from what is universally regarded as the gaseous to what is, in like manner, universally regarded as the liquid state. As a direct result of his experiments, he concludes that the gaseous and liquid states are only widely separated forms of the same condition of matter, and may be made to pass into one another by a series of gradations so gentle that the passage shall nowhere present any interruption or breach of continuity. From carbonic acid as a perfect gas, to carbonic acid as a perfect liquid, the transition may be accomplished by a continuous process, and the gas and liquid are only distant stages of a long series of continuous physical changes. Under certain conditions of temperature and pressure, carbonic acid finds itself, it is true, in a state of instability, and suddenly passes, without change of pressure or temperature, but with the evolution of heat, to the condition which, by the continuous process, can only be reached by a long and circuitous route.

The author discusses the question, as to what is the condition or state of carbonic acid, when it passes at temperatures above 31° from the ordinary gaseous state down to the volume of the liquid, without giving any evidence during the process of the occurrence of liquefaction, and arrives at the conclusion that the answer to this question is to be found in the intimate relations which subsist between the gaseous and liquid states of matter. In the abrupt change which occurs when the gases are compressed to a certain volume at temperatures below the critical point, molecular forces are brought into play, which produce a sudden change of volume, and during this process it is easy to distinguish, by optical characters, the carbonic acid which has collapsed from that which has not changed its volume. But when the same change is effected by the continuous process, the carbonic acid passes through conditions which lie between the ordinary gaseous and ordinary liquid states, and which we have no valid grounds for referring to the one state rather than to the other.

Nitrous oxide, hydrochloric acid, ammonia, sulphuric ether, sulphuret of carbon, all exhibited critical points when exposed under pressure to the required temperatures.

The author proposes for the present arbitrary distinction between vapours and gases, to confine the term vapour to gaseous bodies at temperatures below their critical points, and which therefore can be liquefied by pressure, so that gas and liquid may exist in the same vessel in presence of one another.

The possible continuity of the liquid and solid states is referred to as a problem of far greater difficulty than that which forms the subject of this communication, and as one which cannot be resolved without careful investigation.